

LLNL PuPS Weld Qualification Plan

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August 24, 2001

U.S. Department of Energy

Lawrence
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LLNL PuPS WELD QUALIFICATION PLAN

Revision 2

March 28, 2001

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1) Introduction

This plan ensures the quality of the Lawrence Livermore National Laboratory (LLNL) DOE 3013 Standard Plutonium Packaging System (PuPS) can welds meet the requirements stipulated in the DOE Standard 3013-00 "Stabilization, Packaging, and Storage of Plutonium-Bearing Materials" (Reference 1) and G-ESR-G-00035, Revision 1 dated July 26, 2000, "Savannah River Site Stabilization and Packaging Requirements for Plutonium Bearing Materials for Storage." (Reference 2) This plan also meets the requirements for a weld qualification plan as stipulated in the G-ESR-G-00035.

The Outer Can weld must meet ASME VIII & IX. The Outer Can welds will be evaluated initially and during production. The initial evaluation will be done by performing the following: ASME IX welding procedure qualification, ASME IX operator qualification, and a 25 can Dummy Outer Can (DOC) verification run. During production, product cans and DOCs will be evaluated. Product cans will be evaluated by a combination of visual examination of the weld faces and the use of helium leak checking. The DOCs will be examined by visual examination, leak check, radiographic examination and metallographic examination. Appendix 2 summarizes the requirements of each of these evaluations.

The Inner Can weld must meet the leak tightness requirements of DOE 3013. The Inner Can weld, while not required to meet ASME requirements, will be controlled as described in this plan to ensure a reliable leak path barrier and consistent production processing behavior. The product Inner Cans will be evaluated by a combination of visual examination of the weld faces and the use of helium leak checking.

2) Requirements

These requirements for the welds are described in the documents listed below:

- DOE Standard 3013-00 "Stabilization, Packaging, and Storage of Plutonium-Bearing Materials" (Reference 1),

- G-ESR-G-00035, "Savannah River Site Stabilization and Packaging Requirements for Plutonium Bearing Materials for Storage," Revision 1 dated July 26, 2000 (Reference 2),

- DOE Order 440.1A Attachment 1, Section 6 (Reference 3),

- ASME Boiler and Pressure Vessel Section VIII, Division 1 (Reference 4),

 - This section of the ASME code specifies the requirements for the pressure vessel design, fabrication, examination, and testing. Such requirements as weld penetration, weld shape, maximum size of linear and round defects are included in this section.

- ASME Boiler and Pressure Vessel Section IX (Reference 5)

 - This section of the ASME code specifies the requirements for qualifying the welding procedure and welding operators. It also specified which variables are essential and what range of variation in each essential variable must be held without another procedure qualification.

- ASME Boiler and Pressure Vessel Section V (Reference 6)

 - This section of the ASME code specifies the procedures that must be followed for non-destructive examination (NDE) of pressure vessels.

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In addition to the requirements specified in the above documents, LLNL has imposed additional requirement, as described in this plan, to ensure product quality.

3) Qualification

The following activities will be conducted during the weld qualification phase.

- 3.1 ASME IX Qualification
- 3.2 Twenty Five- Dummy Outer Can Verification Run
- 3.3 Empty Outer Can Weld Tests

3.1 ASME IX Qualification

LLNL Operators become qualified to perform all operations on the PuPS by receiving on-the-job training and performing qualifying welds. The Outer Can welds will be qualified to meet ASME VIII and IX. Operators will become ASME IX qualified by performing one of the following tests:

- 1) Performing a successful PQR weld during the ASME IX qualification. The welds will be radiographically examined, tensile and bend tested per ASME IX, and metallographically examined. Metallographic sections must not show evidence of: lack of fusion, incomplete penetration, or cracks. The metallographic samples will be checked for proper weld depth and width.
- 2) Performing a successful weld on a DOC. Each weld will be sectioned metallographically and the cross sections must meet the requirements of ASME IX, QW-362.

The ASME qualification of the Outer Can weld will be done to all the requirements of ASME Section IX. This specification requires that each “essential variable” be measured and documented during qualification and then controlled during production within ASME-tolerances. The "essential variables" are defined for laser welding in Table QW-264 of ASME IX. Appendix 1, the “PuPS ASME IX Weld Qualification Compliance Matrix,” is a table of these “essential variables,” showing how the LLNL PuPS Program will comply with ASME IX for each of them.

During this qualification, specially fabricated ASME Test Lids, fabricated to Rocky Flats Drawing Number 51604-4426, will be welded to standard 3013 Outer Cans to allow tensile and bend testing of the weld area as required by ASME IX. Only one configuration of process variables will be qualified at this time. Each test part will be assembled and 0.002-in-thick feeler gage stock will be used to ensure a 0.002-in. gap, a condition that exceeds the maximum gap condition expected in production.

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Before welding the ASME IX test parts, part rotation speed and weld power to the workpiece, both ASME essential variables, will be measured to verify they are within the requirements shown in Appendix 3. The plume jet location will also be verified by checking the plume jet reference dimension. The plume jet reference dimension is the distance between the leading edge of the plume jet adjusting bracket and the leading edge of the barrel bracket as shown in BNFL Drawing OBE 15555803.

ASME test welds will be visually, radiographically, and metallographically examined according to the requirements in Appendix 2. Specimens will then be machined from test welds to conduct tensile and bend tests using ASME IX procedures. The final result of these tests will be a Procedure Qualification Record (PQR) for the single configuration of welding parameters and a Welding Procedure Specification (WPS) showing the allowed range of each essential parameter that has been ASME qualified.

Each operator who welds an acceptable ASME IX test part will be ASME IX qualified, and a Welder/Welding Operator Performance Qualification (WPQ) form will be completed to document it.

SRS will review and concur with the WPS. LLNL will be provided the welding WPQs to SRS.

3.2 Twenty Five- Dummy Outer Can Verification Run

3.2.1 Welding

After the ASME qualification of the process and operators, a 25 dummy Outer Can (DOC) verification run will be performed. The DOC test welds uses a normal 3013 Outer Can Lid welded to an Outer Can. Each DOC will contain a mockup of the Inner Can, with surrogate material, to replicate the approximate size, volume, and weight of a production Inner Can. Each surrogate Inner Can will be filled with approximately 5 Kg of surrogate materials. Each surrogate Inner Can will be used with multiple dummy Outer Cans. Each DOC will be processed using the exact same production procedures so that these welds are as close as possible to production joints.

3.2.2 Examination

Each DOC will be leak checked and then visually, radiographically and metallographically examined. Metallographic sections will be taken as specified in Appendix 2. The requirements for each of the above tests and examinations are given in Appendix 2.

The results of the 25 can process verification (radiographs, micrographs, etc.) will be sent to SRS for review and approval before the production run of Outer Cans is started.

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3.3 Empty Outer Can Weld Tests

For the 25 DOC Verification Run and the 1-in-25 lot qualification, each DOC is required by SRS to contain a mockup of the Inner Can to replicate the approximate size, volume, and weight of a production Inner Can. Because of the logistical difficulties anticipated with handling and verifying DOCs filled with surrogate material in a secured plutonium area, LLNL may use Empty Outer Cans (EOCs) for additional weld tests, process troubleshooting, and operator qualification.

EOCs will use a 3013 Outer Can lid welded to a 3013 Outer Can. A hole predrilled through the bottom or cylindrical wall to expedite removal from the Radioactive Management Area (RMA) is optional. Each test can will be welded using the same parameters as production assemblies (unless a special test is being conducted using other parameters). EOCs will be examined to the same requirements as DOCs.

Prior to using EOCs, at least 2 EOCs will be welded and tested like the DOCs mentioned above to verify that this test is representative of welds made in DOCs.

4.0 Process Control and Verification During Production

The activities described below will ensure control and verification of the Inner Can weld/cut processes and Outer Can weld process during production.

4.1 DOC Process Sample Welding

Process monitoring of Outer Can Welds will be conducted by periodically welding and evaluating DOC tests samples. The results of each test sample will be sent to the SRS Design Authority to qualify for acceptance of a maximum 24 previously welded production assemblies. After the first 100 successful production cans, LLNL, with SRS concurrence, may review and change the frequency of the dummy can duration.

The same process data will be recorded for DOC test welds as are recorded for production welds, and each test weld will be leak tested and visually examined the same as production welds. In addition, each test weld will be radiographically and metallographically examined to the requirements of Appendix 2. The results will be tracked to determine process trends and when corrective action should be taken.

4.2 Periodic Variable Verification

There are a number of welding parameters that are not measured during each production weld. These are not expected to change because they are maintained by physical controls in the system. These parameters will be checked periodically to verify that they have not changed. These parameters are the laser power and rotational speed.

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4.2.1 Control of Laser Power.

Weld power to the workpiece is the one ASME-essential variable that is expected to change during production. As the laser flashlamps are used, they slowly deteriorate and the laser output gradually becomes less with time. Therefore, Lumonics, Ltd, the manufacture of the laser, provides a "%Pcal" setting which the user periodically adjusts to compensate for this gradual reduction.

To determine when an adjustment of %Pcal is needed, PuPS Operators will monitor the weld as follows:

- 1) During each production Inner Can Weld, Inner Can cut, and Outer Can weld, the operator will record the laser generated power output of the laser from the Multiwave software. This value is correlated to the delivered power level given in Appendix 3. Appendix 3 shows the recommended power levels for the Inner Can weld, cut and Outer Can Weld. If the correlated delivered laser power level falls outside of these ranges, the PuPS operator will perform a Weld Power Probe Test. The test measures the power delivered by the laser to the workpiece using a commercial calorimeter designed specifically for measuring laser power. During this test, the % Pcal setting of the laser will be adjusted as needed to achieve the nominal power that has been qualified. Changes in the %Pcal will be documented per the LLNL configuration control procedures. The correlation between the generated and delivered power will be confirmed at this time.
- 2) At the beginning of each production day, PuPS Operators will conduct a "Power-at-Laser" test using the laser weld power demand settings. This test operates the laser with the shutter closed. The power is monitored by connecting the laser output signal to a laptop computer and reading the value from the computer screen. This value is correlated to the delivered power level given in Appendix 3. If the correlated value recorded from the Power-at-Laser test falls outside the recommended value range shown in Appendix 3 it will also "trigger" the scheduling of a Weld Power Probe Test, and the same procedure for changing the %Pcal setting described above will be followed.
- 3) A Weld Power Probe Test will be conducted at least once every 2 calendar months of operation or after maintenance is done which could affect this variable, even if none of the above "trigger" events has caused the scheduling of this test. The dates and results of each Weld Power Probe Test will be tracked to assure that the laser power requirements are met. This test will be used to develop the correlation between generated power and delivered power.

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4.2.2 Stepper Motor

Because the rotation speeds of the Inner Can weld, Inner Can cut, and Outer Can weld is controlled by stepper motors, they are not expected to drift from the nominal values. A failure of the motor controller will cause complete stoppage of the system. Periodic DOC Process Sample welds will verify that all variables (including rotation speed) are normal. Also the rotation speed of the stepper motors will be verified once every 2 calendar months of operation or after maintenance is done which could affect this variable.

4.3 Rules for Part Rejection and Work Stoppage

Appendix 3 gives "essential ranges" and recommended ranges for a number of welding parameters. Falling outside of these ranges requires the following actions:

- 1) If any of the variables fall outside of the "essential range" the production assembly will be rejected and corrective actions will be taken.
- 2) If the daily Power-at-Laser Test result falls outside the "essential range," production welding will be stopped until corrective action is taken and/or a Weld Power Probe Test is conducted.
- 3) If the results of the Outer Can Power Probe Test is outside the "essential range". All production assemblies will be rejected that have been welded since the most recent of (a) an acceptable DOC Process Sample Weld, or (b) a Power Probe Test result within the "essential range". After corrective measures have been taken, a EOC or DOC will be processed and examined as described in Section 4.1. If the examinations are acceptable, production welding will commence. LLNL may, at its own risk, start production welding after corrective measures are taken but prior to obtaining the examination results on the EOC or DOC. If the EOC or DOC examinations are acceptable, all production assemblies welded in the time interval are acceptable. If the EOC or DOC examinations are unacceptable, all production assemblies welded in the time interval are also rejected. Further corrective measures will then be taken and another EOC or DOC will be processed and examined until the results are acceptable prior to restarting production welding.
- 4) If production welding is stopped due to PuPS equipment problems that affect weld quality (different than that above) or if a condition or conditions observed during production welding that indicate a change in the normal operation of the PuPS (e.g., melted shield gas shoe, plume jet position change, stepper motor problems, etc.) that affects weld quality, an EOC or DOC shall be processed prior to correcting the problem to determine the acceptability of all prior cans in the lot. This EOC or DOC will be examined as described In Section 4.1. Prior to resuming production welding, the following is required; corrective measures have been taken; an EOC or DOC will be processed and examined as described above. If the examinations are acceptable,

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production welding will commence. If the examination are unacceptable, further corrective measures will be taken and another EOC or DOC will be processed and examined until the results are acceptable prior to restarting production welding.

4.4 Equipment Maintenance and Repair

Routine maintenance and cleaning of the laser heads and fixturing will be done to ensure continued proper operation. A list of these items is shown below with the frequency of each maintenance item. The frequency may be adjusted as experience is gained with the equipment

Maintenance Item	Frequency
1) Outer Can Weld Plume Control Nozzle Inspection and Cleaning (Includes checking position after cleaning)	3 Months
2) Outer Can Weld Shielding Shoe Removal and Maintenance (Includes checking position after cleaning)	3 Months
3) Outer Can Weld Coverglass Cleaning and Replacement	3 Months
4) Outer Can Weld Laser Head Height Check and Adjustment	6 Months
5) Inner Can Weld/Cut Shielding Shoe Removal and Maintenance (Includes checking position after cleaning)	3 Months
6) Inner Can Weld Coverglass Cleaning and replacement	3 Months
7) Inner Can Weld Laser Head Height Check and Adjustment	6 Months
8) Inner Can Cut Coverglass Cleaning and replacement	3 Months
9) Inner Can Cut Laser Head Height Check and Adjustment	6 Months

Prior to maintenance an EOC or DOC will be run to verify that production cans before maintenance are acceptable. An EOC or DOC will also be run after maintenance to verify the system has been returned to production mode successfully. The EOC or DOC will be examined as described in Section 4.1.

4.5 Data Collection

Data collected for the PuPS program includes process variable values, leak test rates, and visual examination results for all production welds and periodic sample welds (EOC and DOC welds). In addition, the EOC and DOC test welds will be evaluated by radiography and metallography. The EOC and DOC are those described in Sections 3.2, 3.3, 4.1, 4.2, 4.3, and 4.4. Also the power to the workpiece and can rotation speed will be verified periodically.

A summary of the data to be collected and the frequency of collection are shown in Appendix 3. This appendix also shows the acceptance requirements for each process variable test and examination. A column titled "essential range" shows those requirements that are necessary for the acceptance of production assemblies. An "NA" in this column indicates that the measurement is not required for product acceptance. A column titled "recommended range" shows a non-binding recommended value for the measurement. When values consistently fall outside this range corrective action will be taken.

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The following paragraphs describe the general methods to be used for data collection.

1. Weld Process Variables

Each production Outer Can weld will be done by an ASME IX-qualified welding operator. The data for the Inner Can weld, Inner Can cut, and Outer Can weld will be collected on run sheets. Laser power will be recorded off of the Multiwave software. All helium flows and pressures will be read from the appropriate meters on the gas panels. These values will be recorded by the operator.

2. Visual Examination

The weld face (visible outside surface) of all welded 3013 Outer Cans and Inner Cans will be visually examined at a magnification of at least 7X to the requirements included in Appendix 2.

3. Power-At-Laser Test

Before each weld, PuPS Operators will conduct a "Power-at-Laser" testing of the laser power demand setting. This test operates the laser with the shutter closed. The power is monitored by connecting the laser output signal to a laptop computer and reading the value from the computer screen. This test will be conducted under the direction of an authorized PuPS operator. This is done as part of the warmup of the laser prior to welding.

4. Radiographic Examination

EOC and DOC welds will be examined per ASME Section VIII, Division 1, UW-51. Porosity requirements are described in ASME Section VIII Appendix 4. These examinations will be performed by personnel certified in radiography to ASNT SNT-TC-1A Level II or higher. Film interpretation will be performed by personnel certified ASNT SNT-TC-1A Level III minimum in radiography.

5. Metallographic Examination

EOC and DOC welds will be sectioned transverse to the travel direction and metallographically examined in at least 4 locations including the slope-in area. A photomicrograph at a minimum 20X magnification will be used to measure and record penetration, width, undercut, porosity, linear indications, and lack-of-fusion.

6. Power Probe Tests

At least every 2 months of operation, power to the work piece will be measure for all 3 laser processes. This will be done using a commercial calorimeter type power probe placed below the laser head being measured. Several tests will be done to ensure repeatability. This test will be conducted under the direction of an authorized PuPS operator.

7. Can Rotation Speed Variation Test

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At least every 2 months of operation, the rotation speed of the stepper motors will be verified by measuring the time of one or more revolutions using a stopwatch with the laser inactive. This test will be conducted under the direction of an authorized PuPS Operator.

4.6 Process Control

Process control will be implemented to ensure that the PuPS weld processes remain in control. The data collected will be tracked by control charts and other appropriate means. The data will be trended to determine when it is approaching the limits stated in Appendix 3.

5.0 System Variables

During qualification, documentation will be provided to the SRS Design Authority defining the condition of key system variables. These variables will not be changed during production without approval of SRS. A complete list of key variables will be made by a joint agreement between LLNL and SRS. The following is a partial list of system variables that will be documented:

- 1) PuPS equipment drawings and revision numbers
- 2) Software revisions
- 3) 3013 component drawings and revision numbers
- 4) 3013 material (lot number, ASME specification number, type or grade, UNS number, P number, group number, and minimum tensile strength)
- 5) Welding Procedure Specifications,
- 6) Accompanying Procedure Qualification Records.

6.0 References

- 1) DOE STD 3013-00, "Stabilization, Packaging, and Storage of Plutonium Bearing Materials, U.S. Department of Energy, 2000.
- 2) SRS Acceptance Specification, "Savannah River Site Stabilization and Packaging Requirements for Plutonium Bearing Materials for Storage," G-ESD-00035, Rev. 1, July 26, 2000.
- 3) DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," U.S. Department of Energy, March 27, 1998.
- 4) ASME VIII, ASME Boiler and Pressure Vessel Code Section VIII, Div. 1(Rules for Construction of Pressure Vessels), 1998
- 5) ASME IX, ASME Boiler and Pressure Vessel Code Section IX (Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators), 1998

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- 6) ASME V, ASME Boiler and Pressure Vessel Code Section V (Nondestructive Examination), 1998

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Appendix 1: PuPS ASME IX Weld Qualification Compliance Matrix

Paragraph		Brief of variables	Essential Variable	Method of Compliance for Qualification	Method of Assurance for Production
QW-402 joints	.1	φ Groove Design	YES	The groove design is set by can and lid design dwg. SRS is the design authority. All cans procured with the same design	N/A Can design fixed.
	.2	± Backing	YES	The backing design is set by can and lid design dwg. SRS is the design authority. All cans procured with the same design	N/A Can design fixed.
	.6	> Fit-up Gap	YES	The gap between lid and can to be measured during qualification. The gaps chosen for qualification exceed the combined can and lid flatness design allowances and represents gaps in excess of those anticipated during production.	Process sampling. The dummy and product cans will have the gap measured prior to welding for process control.
QW-403 Base metals	.1	φ P-Number	YES	The base metal selection (P8 family of SS) is set by can and lid design dwg. SRS is the design authority. All cans procured with same design.	N/A The design dwg. assures base metal is fixed within the P8 family of stainless steels.
	.3	φ Penetration (+/- 10% change)	YES	The thickness design is set by can and lid design dwg. SRS is the design authority. All cans procured with same design. The wall thickness of the can and corresponding step dimension of the lid are fixed.	N/A The can and lid design drawings assure dimensional allowances are well within the EV range.
	.13	φ P-No. 5/9/10	YES	N/A, P8 family of SS are used.	N/A The design dwg. assures base metal is fixed within the P8 family of stainless steels.
	.15	φ P-number	YES	P8 Group 1, assured by the can and lid design dwg. SRS is the design authority. All cans procured with same design. The group and grade will be recorded during qualification.	P8 Group 1, assured by the can and lid design dwg.
+ Addition		- Deletion	> Increase	< Decrease	φ Change

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Appendix 1. PuPS ASME IX Weld Qualification Compliance Matrix (continued)

Paragraph		Brief of variables	Essential Variable	Method of Compliance for Qualification	Method of Assurance for Production
QW-404 Filler metals	.1	φ Cross section or Speed	YES	N/A. No filler material is used for PuPS welding.	N/A. No filler material is used for PuPS welding.
	.2	< t or φ comp	YES		
	.8	± or φ comp.	YES		
	.14	± Filler	YES		
	.20	φ Method of addition	YES		
	.21	φ Analysis	YES		
	.33	φ AWS Class	Non-EV		
QW-406 Preheat	.1	Decrease > 100°F	YES	The welding will be performed at ambient temperature with no pre-heat.	N/A. PuPS Weld operations in B332 will not occur if the room temperature is more than 40° below ambient temperature.
QW-407 PWHT	.1	φ PWHT	YES	N/A. There will be no post-weld heat treatment	N/A
QW-408 Gas	.2	φ Single, Mixture, or %	YES	The process utilizes a single industrial grade He gas, no mixture.	N/A. The procurement QA process assures He gas is utilized.
	.6	φ Environment	YES	The weld chamber contains ambient air at time of welding. No design changes for other chamber gas atmospheres are anticipated.	N/A. No design changes for other chamber gas atmospheres are anticipated
	.11	± Gases	YES	Single gas (He) is utilized for plume jet and shielding shoe. There is no backing gas. The He gas knife used for cover glass protection is not an essential variable.	N/A. No design changes for other inert gases are anticipated.
	.12	φ >5% Gases	YES	Flow rates for the gas streams will be recorded during qualification.	Flow rates for the gas streams will be recorded during production for process control.
	.13	φ Plasma jet position	YES	Plasma jet orientation is fixed by BNFL design and is not anticipated to be modified. The orientation of jet position will be recorded at time of qualification. The system also uses a gas knife and shielding shoe	N/A. The plume jet position measurements will be taken at specific times (Section 4.4).
+ Addition		- Deletion	> Increase	< Decrease	φ Change

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Appendix 1. PuPS ASME IX Weld Qualification Compliance Matrix (continued)

Paragraph		Brief of variables	Essential Variable	Method of Compliance for Qualification	Method of Assurance for Production
QW-409 Electrical Characteristics	.19	φ Pulse	YES	N/A. The Lumonics 2000 laser system is continuous wave.	N/A. Controlled by equipment design. The Lumonics system is not anticipated to change.
	.20	φ Mode, energy	YES	N/A. The Lumonics 2000 laser system is gaussian.	N/A. Controlled by equipment design. The Lumonics system is not anticipated to change
	.21	φ Power, speed, d/fl, distance	YES	<p>Power – The power at the work piece will be recorded at time of qualification utilizing calibrated power pucks. The laser settings will be recorded for information. Maximum variation allowed is 5%</p> <p>Speed – The can rotational speed will be recorded at time of qualification. The maximum variation allowed is 2%.</p> <p>Beam Dia./Focal length – The beam diameter and focal length settings will be recorded at time of qualification. The maximum variation is 2%.</p> <p>Distance – The distance from the weld head to the can is controlled by fixture design. The distance will be recorded at time of qualification. The maximum variation is 2%.</p>	<p>Power – The power at the work piece will be recorded at specific times (Section 4.2.1.3) for process control utilizing calibrated power probes. The laser settings will be recorded for information trending.</p> <p>Speed – N/A. The can speed is controlled by equipment design. This will also be checked at specific times (Section 4.2.2)</p> <p>Beam Dia./Focal length - fixed by lens.</p> <p>Distance – The distance from the weld head to the can is controlled by fixture design. The distance will be recorded at specific times (Section 4.4)</p>
+ Addition		- Deletion	> Increase	< Decrease	φ Change

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Appendix 1. PuPS ASME IX Weld Qualification Compliance Matrix (continued)

Paragraph		Brief of variables	Essential Variable	Method of Compliance for Qualification	Method of Assurance for Production
QW-410 technique	.5	φ Method of cleaning	Non - EV	Although not an EV, the method of cleaning will be recorded during qualification.	The method of cleaning will be included in the PuPS welding guidance.
	.7	φ Oscillation	YES	N/A. The Lumonics 2000 laser system is stationary beam. A statement to this effect will be added to the weld qualification documentation	N/A. Controlled by equipment design. The Lumonics system is not anticipated to change
	.14	φ Angle of beam axis	YES	The angle of the beam axis is fixed by fixture design. A sketch will be recorded during qualification period to display orientation.	N/A. The angle will be verified as unchanged as defined in Section 4.4.
	.17	φ Type of equipment	YES	The Lumonics 2000 laser system will be used for qualification. A statement to this effect will be added to the weld qualification documentation	N/A. Controlled by equipment design. The Lumonics system is not anticipated to change
	.20	+ Wash pass	YES	The automated welding program does not utilize a wash pass. A statement to this effect will be added to the weld qualification documentation	N/A. Controlled by process design. The automated weld program is not anticipated to change.
	.21	1 vs. 2 side welding	YES	The automated welding program, fixturing design, can design, and process design utilizes single side weld. A statement to this effect will be added to the weld qualification documentation	N/A. Controlled by process design. The automated weld program is not anticipated to change.
	.37	φ Single to multi pass	YES	The automated welding program does not incorporate a multi-pass weld process. An overlap is utilized to assure complete weld coverage. A statement to this effect will be added to the weld qualification documentation	N/A. Controlled by process design. The automated weld program is not anticipated to change.
+ Addition		- Deletion	> Increase	< Decrease	φ Change

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 2: PuPS Inspection and Test Requirements

1.0 Outer Can Weld

1.1 Visual Examination at 7X min.

1.1.1 Minimum weld face width shall be 0.075 in.

- a) Source: The weld widths of the first 29 of the 60-can Broomfield run ranged from 0.085 in. to 0.135 in. The average was 0.1136 in. with a standard deviation of 0.0136 in. The acceptance requirement is the average minus 3 standard deviations.
- b) This will be reevaluated as part of the 25-can verification run.

1.1.2 Weld face centerline-to-lid-edge shall be 0.1575 ± 0.010 in.

- a) The variation of this value observed in the 25-can verification welds will be used to establish a tolerance requirement.
- b) Source: The nominal distance from the edge of the lid to the weld-parting plane is 0.1575 in. Metallographic examination of cans made during the Broomfield 60-can run has shown that the centerline of the weld face is offset from the centerline of the weld root by an average of 0.0075 in. toward the lid edge. Early results from B371 weld examinations indicate less offset than experienced in Broomfield. Therefore, measurements of the weld face and weld root centerline-to-lid-edge will be made on the verification cans and used to determine process control value.

1.1.3 The weld surface shall be free of voids > 0.030 in. dia.

- a) Source: ASME VIII Section UW-51 (b) 4 and Appendix 4 specify that no voids > 0.030 in. (1/4 of the section thickness) be detected by radiographic examination. We will not radiograph these joints in production, but will apply the same porosity standard to the weld surface.

1.1.4 The weld surface shall show no evidence of lack of fusion or cracks.

1.1.5 Weld undercut shall not exceed 0.012 inch.

- a) Source: ASME VIII Section UW-35.

1.2 Helium Leak Check

1.2.1 The helium leak rate shall be below 1×10^{-7} std cm³/sec.

- a) Source: DOE-STD-3013-00 Section A.6.2.3.2

1.3 Radiographic Examination

Each Empty Outer Can (EOC) or Dummy Outer Can (DOC) shall be examined by 100% radiography per UW-51 of ASME Section VIII, Division 1. The radiographic film shall be interpreted by personnel who are Level III certified in radiography per the American Society for Nondestructive Testing, Inc. (ASNT) "Recommended Practice for Nondestructive Testing Personnel Qualification and Certification," SNT-TC-1A.

LLNL PuPS WELD QUALIFICATION PLAN

1.4 Metallographic Examination

1.4.1 Can Sectioning

Each Empty Outer Can or Dummy Outer Can weld will be sectioned transverse to the weld direction in at least four (4) locations to include one at the weld tie-in, one in the overlap area, one in the body of the weld, and one at the weld stop-start area.

(Source SRS 1.d)

1.4.2 Sample Examination

Each cross section will be suitable etched and photographed at a minimum of 20X magnification. The weld and heat-affected zone shall be examined to ensure complete penetration of the joint and freedom from cracks and lack of fusion. (Source SRS 1.d)

1.4.3 Minimum weld penetration shall be 0.118 in. (to the step).

a) Source: ASME VIII Section UW-13, Figure UW-13.2d requires a full penetration weld.

1.4.4 The weld surface shall be free of voids > 0.030 in. dia.

a) Source: ASME VIII Section UW-51 (b) 4 and Appendix 4 specify that no voids > 0.030 in. (1/4 of the section thickness) be detected by radiographic examination. This criterion is for detection by radiographic examination, we are choosing to apply the same standard to the metallographic examinations also.

1.4.5 The a+b/2ts ratio must be 1.00 or greater.

a) Source: ASME VIII Section UW-13, Figure UW-13.2d requires a full penetration weld.

1.4.6 The weld surface shall show no evidence of lack of fusion or cracks.

1.4.7 Weld thickness reduction shall not exceed 0.012 in.

a) Source: ASME VIII Section UW-35b2 requires that weld thickness reduction shall not exceed 10% of the section thickness.

2.0 Inner Can Weld

2.1 Visual Examination at 7X min.

2.1.1 The weld shall show complete fusion around the circumference, be free of cracks and surface porosity.

a) Source: DOE-STD-3013-00 requires the weld to be leak tight. This implies that the weld has complete fusion around the circumference, and no through the wall cracks or porosity. These examinations are for process monitoring only.

2.2 Helium Leak Check

2.2.1 The helium leak rate shall be below 1×10^{-7} std cm^3/sec .

a) Source: DOE-STD-30130-00 Section A.6.2.3.2

2.3 Surface Contamination

2.3.1 The exterior of the Inner Can shall not exceed 2000 dpm/100 cm^2 .

a) Source: DOE-STD-3013-00 Section 6.2.4.2

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 3: LLNL PuPS Data Collected for Laser Weld Process Control

Frequency	Process or Procedure	Measured Item	Essential Range	Recommended Range
Every Production Weld	PuPS Operation Inner Can Weld	Date	Required Data	Required Data
		Operator's Name	Required Data	Required Data
		Assistant's Name	NA	Optional
		Convenience Can # (s)	Required Data	Required Data
		Can Tare Weight(s)	Required Data	Required Data
		Can Net Weight(s)	Required Data	Required Data
		Convenience Can LOI(s)	Required Data	Required Data
		Recorded Gross Weight(s)	Required Data	Required Data
		Verified Gross Weight(s)	Required Data	Required Data
		Calculated Weight Gain(s)	< 0.1g	< 0.1g
		Inner Can Number	Required Data	Required Data
		Bung Number	Required Data	Required Data
		Helium Purge Pressure	NA	> 2 psig
		Helium Purge Flow	NA	0.9 m ³ /hr
		Delivered Inner Can Weld Laser Power	NA	1378- 1450 -1522 Watts
		Helium Weld Purge Pressure	NA	49- 52 - 54 psig
		Helium Weld Purge Flow	NA	6.7- 7.0 - 7.3 m ³ /hr
		Shielding Shoe Pressure	NA	35- 37 - 38.5 psig
		Shielding Shoe Flow	NA	20- 21 - 22 m ³ /hr
		ΔP Before Weld (Cupboard to Room)	NA	NA
		ΔP Before Weld (Glovebox to Cupboard)	NA	NA
		ΔP During Weld (Cupboard to Room)	NA	NA
		ΔP During Weld (Glovebox to Cupboard)	NA	< -.5" wg
		Delivered Inner Can Cut Laser Power	NA	1568-1650-1732 Watts
		Co-Axial Head Pressure	NA	67- 70 -74 psig

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 3: LLNL PuPS Data Collected for Laser Weld Process Control (continued)

Frequency	Process or Procedure	Measured Item	Essential Range	Recommended Range
Every Production Weld	PuPS Inner Can Weld and Cut Inspection	Weld Fusion	Complete	Complete
		Leak Rate	$<1 \times 10^{-7}$ std cc/sec He	$<1 \times 10^{-7}$ std cc/sec He
		Leak Time	NA	< 5 minutes
		Removable Contamination	< 20 dpm $\alpha/100$ cm ²	< 20 dpm $\alpha/100$ cm ²
		Total Contamination	<500 dpm $\alpha/100$ cm ²	<500 dpm $\alpha/100$ cm ²
		Dose Rate <input type="checkbox"/> @ contact	Required Data	Required Data
		Dose Rate <input type="checkbox"/> @ 30 cm	Required Data	Required Data
		Dose Rate <input type="checkbox"/> @ contact	Required Data	Required Data
		Dose Rate <input type="checkbox"/> @ 30 cm	Required Data	Required Data
		Final Gross Weight	Required Data	Required Data

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 3: LLNL PuPS Data Collected for Laser Weld Process Control (continued)

Frequency	Process or Procedure	Measured Item	Essential Range	Recommended Range
Every Production Weld	PuPS Operation Outer Can Weld	Date	Required Data	Required Data
		Operator's Name	Required Data	Required Data
		Assistant's Name	NA	Optional
		Inner Can Number	Required Data	Required Data
		Inner Can Gross Weight	Required Data	Required Data
		Outer Can Number	Required Data	Required Data
		Lid Number	Required Data	Required Data
		Helium Backfill Pressure	NA	> 2 psig
		Gap Measurement	≤ 0.002 in	≤ 0.0015 in
		Delivered Outer Can Weld Laser Power	1626- 1712 -1798 Watts	1644- 1712 -1780 Watts
		Purge Head Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Purge Head Flow	95- 100 - 105 lpm	95- 100 - 105 lpm
		Shield Shoe Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Shield Shoe Flow	76- 80 - 84 lpm	76- 80 - 84 lpm
		Plasma Plume Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Plasma Plume Flow	26.6- 28.0 - 29.4 lpm	26.6- 28.0 - 29.4 lpm
		ΔP (cupboard to room)	NA	< -0.5" wg
	PuPS Outer Can Weld Inspection	Weld Width	≥ 0.075 in.	≥ 0.075 in.
		Weld C.L.-to-edge dimension	0.1575 ± 0.010 in.	0.1575 ± 0.010 in.
		Voids	None >0.030	None >0.030
		Cracks	None Allowed	None Allowed
		Weld Undercut	< 0.012 in	< 0.012 in
		Leak Rate	<1 x 10 ⁻⁷ std cc/sec He	<1 x 10 ⁻⁷ std cc/sec He
		Leak Time	NA	< 5 minutes
		Removable Contamination	< 20 dpm α/100 cm ²	< 20 dpm α/100 cm ²
		Total Contamination	<500 dpm α/100 cm ²	<500 dpm α/100 cm ²
		Dose Rate γ @ contact	Required Data	Required Data
		Dose Rate γ @ 30 cm	Required Data	Required Data
		Dose Rate η @ contact	Required Data	Required Data
		Dose Rate η @ 30 cm	Required Data	Required Data
		Final Gross Weight	Required Data	Required Data

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 3: LLNL PuPS Data Collected for Laser Weld Process Control (continued)

Frequency	Process or Procedure	Measured Item	Essential Range	Recommended Range
Empty Outer Can (EOC) or Dummy Outer Can (DOC) Test Weld: 1 in 25 Production Welds.	PuPS Operation Outer Can Weld	Date	Required Data	Required Data
		Operator's Name	Required Data	Required Data
		Assistant's Name	NA	Optional
		Inner Can Number	Required Data	Required Data
		Inner Can Gross Weight	Required Data	Required Data
		Outer Can Number	Required Data	Required Data
		Lid Number	Required Data	Required Data
		Helium Backfill Pressure	NA	> 2 psig
		Gap Measurement	< 0.002 in	< 0.0015 in
		Delivered Outer Can Weld Laser Power	1626- 1712 -1798 Watts	1644- 1712 -1780 Watts
		Purge Head Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Purge Head Flow	95- 100 - 105 lpm	95- 100 - 105 lpm
		Shield Shoe Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Shield Shoe Flow	76- 80 - 84 lpm	76- 80 - 84 lpm
		Plasma Plume Pressure	5.7- 6.0 - 6.3 bar	5.7- 6.0 - 6.3 bar
		Plasma Plume Flow	26.6- 28.0 - 29.4 lpm	26.6- 28.0 - 29.4 lpm
		ΔP (cupboard to room)	NA	< -0.5" wg
	PuPS Outer Can Weld Inspection	Weld Width	≥ 0.075 in.	≥ 0.075 in.
		Weld C.L.-to-edge dimension	0.1575 ± 0.010 in.	0.1575 ± 0.010 in.
		Voids	None >0.030	None >0.030
		Weld Undercut	< 0.012 in	< 0.012 in
		Leak Rate	<1 x 10 ⁻⁷ std cc/sec He	<1 x 10 ⁻⁷ std cc/sec He
		Leak Time	NA	< 5 minutes
		Final Gross Weight	Required Data	Required Data
	Radiographic Inspection Procedure	ASME VIII, UW-51	ASME VIII, UW-51	ASME VIII, UW-51
	Weld Metallographic Examination	Weld Penetration	≥ 0.118 in.	≥ 0.130 in.
		Undercut	≤ 0.012 in	≤ 0.012 in
		Cracks	None allowed	None allowed
		Maximum void size	≤ 0.030 in	≤ 0.030 in
		Lack of Fusion	None allowed	None allowed

LLNL PuPS WELD QUALIFICATION PLAN

Appendix 3: LLNL PuPS Data Collected for Laser Weld Process Control (continued)

Frequency	Process or Procedure	Measured Item	Essential Range	Recommended Range
Once every 6 months	Laser Power Probe Tests	Delivered Inner Can Weld Laser Power	NA	1378- 1450 -1522 Watts
		Delivered Inner Can Cut Laser Power	NA	1568- 1650 -1732 Watts
		Delivered Outer Can Weld Laser Power	1626- 1712 -1798 Watts	1644- 1712 -1780 Watts
	Rotation Speed Test	Inner Can Weld	NA	392- 400 -408 °/min
		Inner Can Cut	NA	433- 442 -480 °/min
		Outer Can	510- 520 -530 mm/min	510- 520 -530 mm/min